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THE THERMODYNAMICS OF THE SILICON CARBIDE/SILICON-CARBON VAPOR SYSTEM

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PREFACE

This RAND Memorandum is a continuation of a broad study originally requested in 1962 by the Scientific Advisor to the Physics Division, Research Directorate, * Air Force Special Meapons Center, Kirtland Air Force Base, New Mexico.

It is a contribution to a better understanding of the complex problems involved in the physics of reentry bodies. Silicon carbide is the fourteenth of a series of ablative materials to be investigated by means of mathematical techniques similar to those used at RAMD in the parametric study of certain low-molecular-weight compounds as nuclear rocket propellants.

The results of the investigation of graphite, polystyrene, polyethylene, phenol-formaldehyde resin, polyamide resin, taflon, silica, sirconia, magnesia, alumina, beryllia, calcia, and magnesium silicate, the first thirteen materials to be studied in the series, are reported in BAND Memoranda MM-3326-1-PR, The Thermodynamics of the Graphite/ Carbon Vanor System; BM-3708-PR, The Thermodynamics of the Polystyrane/ Budrocarbon Yener System; RM-3709-FR, The Thermodynamics of the Polyethyless/Swirocarbon Vasor System; Mi-3988-FR, The Thermodynamics of the Phenol-Formeldehyde Regin/Carbon-Hydrogen-Grysen Veror System; BM-4404-PR, The Thermodynamics of the Polyanida Rasin (Eylon-6)/Carbon-Mydrosen-Grysen-Hitrosen Vasor System; M-4634-PR, The Thermodynamics of the Teflen/Fluorocarbon Vasor System; RM-4804-FR, The Thermodynamics of the Silica/Silicon-Oryson Vanor System; Mi-4907-PR, The Thermodynamics of the Zirconia/Zirconius-Grysen Vasor System; Bi-4943-PR, The Thermodynamics of the Masnesia Masnesium-Orygan Vanor System; 36-5043-FR, The Thermodynamics of the Alumina/Aluminum-Grypan Vanor frems; M-5151-PR, The Thermodynamics of the Jarville/Jervillum-Correct Yanor System; BM-5248-PR, The Thermodynamics of the Calcia/Calcium-Orresp Vapor System; and Mi-5337-FR, The Thermodynamics of the Massasium . Hilicare Messaelun-Hilicon-Orysen Vanor System.

Now the Air Force Weapons Laborator,.

SUMMARY

The purpose of this study is the thermodynamic investigation of silicon carbide, SiC, over a range of temperatures up to 6000° K and pressures up to 10^{3} atmospheres.

Two sets of equilibrium composition equations are used--one representing a pure gas phase, the other a heterogeneous system of gas and condensed (i.e., solid) silicon carbide. The gas phase of the heterogeneous chemical system, like the homogeneous gas phase, comprises 25 gaseous silicon-carbon species.

The results of the computational program are presented in both tabular and graphic form. The latter is a conventional Mollier diagram in which specific enthalpy is plotted against specific entropy, with cross plots of temperature, pressure, and molecular weight or moles of condensed silicon carbide.

ACKNOWLE DOMENTS

This study involved a considerable amount of hand and machine computation. The efforts of the following RAND Physics Department staff members are gratefully acknowledged: Donald A. Brown, for his extensive programming and machine work; and Elizabeth J. Force, for her meticulous graphical presentation of the tabulated results.

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I. INTRODUCTION

This study considers a chemical system that under certain conditions of temperature and pressure is a pure gas mixture and under others is a disperse system, i.e., smoke. In this case the smoke is a gas that contains a condensed phase, solid silicon carbide, symbolized by <u>SiC</u>.

The following assumptions were made in the computations:

- (1) Thermal equilibrium is maintained between the condensed particles and the gas phase.
- (2) The pressure due to the thermal motion of the condensed particles can be neglected.
- (3) The gas phase obeys the ideal-gas law.
- (4) The volume coefficient of thermal expansion of the condensed phase is constant.
- (5) The solid phase is cubic, or beta, silicon carbide.
- (6) Silicon carbide does not decompose at 3259°K.

II. COMPOSITION EQUATIONS

In this study it is assumed that the gas formed by heating silicon carbide, SiC, at various pressures up to a temperature of 6000° K is a mixture involving twenty-five gaseous chemical species--C, C₂, C₃, C₄, C₅, C₆, C₇, C₈, C₉, C₁₀, e⁻, C⁻, C₂, C⁺, C⁺², C⁺³, C⁺⁴, C⁺⁵, C⁺⁶, SiC, Si₂C, SiC₂, Si, Si₂, Si₃--and one condensed species--SiC (solid). The presence of a condensed phase makes it necessary to consider two distinct sets of chemical equations.

A. No condensed phase present. In terms of Si, C, and e as primary components 1, 2, and 3, the chemical equations for the secondary components, or derived species, are given by the expression

$$a_i Si + b_i C + c_i e^- = Si_{a_i} C_{b_i} e^-_{c_i},$$
 (1)

where the coefficients a, b, and c, have the following values:

			Compo	pent i
<u>*</u>	b _1	c _i	Symbol	Number
	2		C ₂	4
	3		C ₂ C ₃ C ₄ C ₅ C ₆ C ₇ C ₈ C ₉ C ₁ C ₂ C ₇ C ₈ C ₉ C ₁ C ₂ C ₇ C ₈ C ₉ C ₁ C ₂ C ₇ C ₈ C ₉ C ₁ C ₂ C ₇ C ₈ C ₉ C ₁ C ₁ C ₂ C ₇ C ₈ C ₉ C ₁ C ₁ C ₂ C ₇ C ₈ C ₉ C ₁ C ₁ C ₁ C ₂ C ₃ C ₄ C ₇ C ₈ C ₁ C ₁ C ₂ C ₁ C ₂ C ₁ C ₂ C ₁ C ₂ C ₃ C ₄ C ₇ C ₈ C ₉ C ₁ C ₁ C ₂ C ₁ C ₂ C ₁ C ₂ C ₃ C ₄ C ₇ C ₈ C ₉ C ₁ C ₁ C ₂ C ₁ C ₂ C ₄ C ₇ C ₈ C ₉ C ₁ C ₁ C ₂ C ₄ C ₇ C ₈ C ₉ C ₁ C ₁ C ₂ C ₄ C ₇ C ₈ C ₉ C ₉ C ₉ C ₁ C ₉	5
	4		c <u>,</u>	6
	5		c _s	7
	6		c ₆	8
	7		c ₇	9
	8		cg	10
	3		c ₉	11
	10		c ₁₀	12
	1	1	c ⁻	13
	2	1	c ₂ -	14
	1	-1	C.	15
	1	-2	c ⁺²	[±] 16
	1	-3	c ⁺³	17

Com	DODE	ant	1

4,	b _1	c ₁	Symbo 1	Number
	1	-4	c ⁺⁴	18
	1	- 5	c ⁺⁵	19
	1	-6	c ⁺⁶	20
1	1		SIC	21
2	1		Si ₂ C	22
1	2		SiC ₂	23
2			Si ₂	24
3			si3	25

The mass-balance equations are

$$n_{Si} = 1 - \sum_{4}^{25} a_{i} n_{i},$$
 (2)

$$n_{C} = 1 - \sum_{i=1}^{25} b_{i} n_{i},$$
 (3)

and

$$n_{e^{-}} = -\sum_{i=1}^{25} c_{i} n_{i}, \qquad (4)$$

where n_{Si} , n_{C} , and n_{e^-} are the numbers of moles of Si, C, and e^- , respectively, a_i , b_i , and c_i are the coefficients of Si, C, and e^- , on the left-hand side of Eq. (1), and n_i is the corresponding number of moles of component i.

The equilibrium equations are given by the expression

$$n_{i} = K_{i}(P/n)^{a_{i}^{+b_{i}^{+c}} - 1} (n_{Si})^{a_{i}} (n_{C})^{b_{i}} (n_{e^{-}})^{c_{i}},$$
 (5)

where n is the total number of moles of gas in the equilibrium mixture, P is the total pressure in atmospheres, and $K_{\underline{i}}$ is the thermodynamic equilibrium constant of component i computed on the basis of Eq. (1).

B. <u>Solid SiC present</u>. In terms of <u>SiC</u> (solid), C, and e as primary components 1, 2, and 3, the secondary components, or derived species, may be obtained from the following generalized chemical equation:

$$a_{j}\underline{s_{1}c} + b_{j}c + c_{j}e^{-} = s_{1}a_{j}c_{b_{j}}e^{-}c_{j}$$
 (6)

The coefficients a_j , b_j , and c_j , as well as the corresponding derived species, are listed in the following table.

			Component j	
a j	<u>b</u> j	c _j	Symbol	Number
_	2		С,	4
	3		c ₂ c ₃ c ₄ c ₅ c ₆ c ₇ c ₈ c ₉ c ₁₀	5
	4		cμ	6
	5		c ₅	7
	6		c _e	8
	7		C ₇	9
	8		c ₈	10
	9		C ₉	11
	10		c ₁₀	12
	1	1	C ²	13
	2	1	c ₂ -	14
	1	-1	c+	15
	1	-2	c ⁺²	16
	1	-3	c ⁺³	17
	1	-4	c ⁺⁴	18
	1	-5	c ₂ " c+ c+2 c+3 c+4 c+5 c+6	19
	1	-6	c ⁺⁶	٥

			Component j		
4)	<u>b</u> 1	رء	Symbo 1	Number	
1			SIC	21	
2	-1		s ₁₂ c	22	
1	1		Sic ₂	23	
1	-1		Si	24	
2	-2		Si ₂	25	
3	-3		Si ₃	26	

The mass-balance equations are

$$n_{\underline{SiC}} = 1 - \sum_{4}^{26} a_{j} n_{j},$$
 (7)

$$n_{C} = -\sum_{i}^{26} b_{j} n_{j}, \qquad (8)$$

and

$$n_{e^{-}} = -\sum_{4}^{26} c_{j}^{n}_{j},$$
 (9)

where $n_{\underline{SiC}}$, $n_{\underline{C}}$, and $n_{\underline{e}}$ are the numbers of moles of \underline{SiC} , C, and \underline{e} , respectively, \underline{a}_{j} , \underline{b}_{j} , and \underline{c}_{j} are the coefficients of \underline{SiC} , C, and \underline{e} , in Eq. (6), and \underline{n}_{j} is the corresponding number of moles of component j.

The equilibrium equations are obtained by considering the free energy F of the system and the partial molar free energy, or chemical potential, $\mu_{\rm X} = \partial F/\partial n_{\rm X}$ of each component. For an ideal gas

$$\mu_{x} = \mu_{x}^{0} + RT \ln (n_{x}P/n),$$
 (10)

where μ_X^0 is the chemical potential of component x in the standard state of unit partial pressure, R is the gas constant, T is the temperature, P is the pressure, and n is the total number of moles

of gaseous species in the mixture. The chemical potential for <u>S1C</u> is given by

$$\mu_{\underline{SiC}} = \mu_{\underline{SiC}}^{\circ} + (P-1)\overline{V}_{\underline{SiC}}, \qquad (11)$$

where $\mu^{\circ}_{\underline{SiC}}$ is the standard molar free energy for \underline{SiC} , $\overline{V}_{\underline{SiC}}$ is the molar volume of \underline{SiC} , and P is the pressure of the system.

By combining Eqs. (10) and (11), keeping in mind that the subscript j refers to the derived species on the right-hand side of Eq. (6), the following expression is obtained

$$n_j = K_j \exp \left[a_j (P-1) \bar{V}_{\underline{SiC}}/RT\right] (P/n)^{b_j+c_j-1} (n_C)^{b_j} (n_{e^-})^{c_j}.$$
 (12)

In Eq. (12), K_j is the thermodynamic equilibrium constant associated with the chemical reaction of Eq. (6) and is defined by the relation

$$\Delta F^{O} = \mu_{j}^{O} - a_{j} \mu_{SiC}^{O} - b_{j} \mu_{C}^{O} - c_{j} \mu_{e}^{O} = - RT \ln K_{j}.$$
 (13)

At first glance, Eqs. (7), (8), (9), and (12) represent a mathematical system of twenty-five equations in twenty-five unknowns that, ordinarily, could be solved by simple iteration. From the standpoint of the Gibbs phase rule, however, the chemical system under consideration, consisting of one component and two phases, enjoys but one degree of freedom. This means that at an arbitrarily fixed temperature, solid and vapor are in equilibrium at a unique pressure which can be determined in the following manner.

The expression for the total pressure as the sum of the partial pressures is

$$P = \sum_{n=1}^{26} n_{x} P/n, \qquad (14)$$

where n is the total number of moles of gas in the equilibrium mixture. In view of Eq. (12) the above expression becomes

$$P = P_{C} + P_{e^{-}} + \sum_{i=1}^{26} K_{j} (\exp a_{j}Q) (P_{C})^{b_{j}} (P_{e^{-}})^{c_{j}}, \qquad (15)$$

where P_C and P_e are the partial pressures of C and e, respectively, and Q represents the quantity $(P-1)\tilde{V}_{\underline{SiC}}/RT$. In like manner, Eqs. (8) and (9), when multiplied through by P/n and rearranged, become

$$\emptyset = P_{C} + \sum_{i=1}^{26} b_{j} K_{j} (\exp a_{j} Q) (P_{C})^{b_{j}} (P_{e^{-i}})^{c_{j}}, \qquad (16)$$

and

$$\emptyset = P_{e^{-}} + \sum_{i=1}^{26} c_{j} K_{j} (\exp a_{j} Q) (P_{C})^{b_{j}} (P_{e^{-}})^{c_{j}}, \qquad (17)$$

where # represents zero. Equations (15), (16), and (17) represent a system of three equations in three unknowns, P, P_C , and P_{e^-} , which can be solved by iteration. It is then a simple matter to solve for P_j , n_j , and n.

III. THREMODYNAMIC EQUATIONS

The molecular weight of the gas-SiC mixture is given by the relation

$$M = \frac{40.097}{n},$$
 (18)

where 40.097 is the formula weight of the input material SiC and \hat{n} is the total number of moles in the mixture.

The specific free energy (in calories per gram) of the mixture is given by the expression

$$f = \frac{1}{40.097} \left\{ \sum_{i=1}^{8} n_{i} \left[\mu_{i}^{0} + RT \ln (n_{i}P/n) \right] + n_{\underline{SiC}} \left[\mu_{\underline{SiC}}^{0} + c(P-1) \vec{v}_{\underline{SiC}} \right] \right\},$$

which is derived from Eqs. (5) and (6). The summation is over all gaseous species. The constant c = 0.0242172 converts cc-atmospheres to calories.

The specific entropy (in calories per degree per gram) of the mixture is given by the expression

$$= \frac{1}{40.097} \left\{ \sum_{i=1}^{8} n_{i} \left[s_{i}^{o} - R \ln (n_{i}P/n) \right] + n_{\underline{SiC}} \left[s_{\underline{SiC}}^{o} - c_{V}(P-1) \nabla_{\underline{SiC}} \right] \right\},$$
(20)

where S_1^0 and $S_{\underline{SiC}}^0$ are the standard molar entropy of component i and \underline{SiC} , respectively, at a given temperature, and α_v is the volume coefficient of thermal expansion of \underline{SiC} .

The specific enthalpy (in calories per gram) of the gas mixture is given by the expression

$$h = \frac{1}{40.097} \left\{ \sum_{i=1}^{g} n_{i} H_{i}^{0} + n_{\underline{SiC}} \left[H_{\underline{SiC}}^{0} + c(1 - \alpha_{V}^{T})(P - 1) \nabla_{\underline{SiC}} \right] \right\}, (21)$$

where H_{1}^{0} and $H_{\underline{SiC}}^{0}$ are the standard molar heat content of component i and \underline{SiC} , respectively, at a given temperature.

The specific internal energy (in calories per gram) of the mixture is given by the expression

$$u = \frac{1}{40.097} \left\{ \sum_{i=1}^{8} n_{i} (H_{i}^{0} - RT) + n_{\underline{SiC}} \left[H_{\underline{SiC}}^{0} - c[1 + (P - 1)\alpha_{V}T] \bar{V}_{\underline{SiC}} \right] \right\}.$$
(22)

The terms representing the increase in a thermodynamic property from one atmosphere to P atmospheres for <u>SiC</u>, namely,

$$\Delta \mathbf{F} = (\mathbf{P} - 1)\hat{\mathbf{V}}_{\mathbf{SiC}}, \tag{23}$$

$$\Delta S = -\alpha_{v}(P - 1)\tilde{V}_{\underline{SiC}}, \qquad (24)$$

$$\Delta H = (1 - \alpha_v^T)(P - 1)^{\nabla}_{SiC}, \qquad (25)$$

$$\Delta U = -\alpha_{V}^{T}(P-1)\bar{V}_{SiC}, \qquad (26)$$

are readily derived from the differential formulas relating the various thermodynamic functions. Each of the above terms must be multiplied by the factor c = 0.0242172 to convert it from cc-atmospheres to calories.

The specific volume of the mixture (in cubic centimeters per gram) is given by the expression

$$v = \frac{1}{40.097} \left\{ nRT/P + n_{\underline{SiC}} \bar{v}_{\underline{SiC}} \right\},$$
 (27)

where the first term in the braces is the volume of the gas phase and the second term is that of the condensed phase.

IV. BASIC DATA

The pertinent thermodynamic properties (heat content, entropy, free energy, and heat of formation) for this study were taken from three sources: <u>JANAF Thermochemical Data</u>, (1) Duff and Bauer, (2) and F. R. Gilmore. (3) The molecular weights and heats of formation of the various components are listed in the following table.

Species SiC(8,s)	Molecular Weight 40.097	Heat of Formation at 0°K (cal/mole)	Reference
SiC(g)	40.097	-17,261	- 1
Si ₂ C	68.183	170,806	1
SiC ₂	52.108	127,068	1
Si		145,631	1
	28.086	106,664	1
si ₂	56.172	140, 324	1
Si ₃	84.258	151,219	1
С	12.011	169,576	1
c ₂	24.022	197,000	1
c ₃	36.033	188,104	1
c ₄	48.044	240,500	1
c _s	60.055	240,298	1
c ₆	72.066	287,000	2
c ₇	84.077	287,000	2
c ⁸	96.088	339,000	2
c ₉	108.099	334,000	2
c ₁₀	120.110	393,000	2
e ¯	0.0005489	. 0	1
c-	12.0115	140,800	1
c ₂ c+	24.0225	125,500	1
C+	12.0105	429,623	3
c ⁺²	12.0099	991,894	3
c ⁺³	12.0094	2,096,127	3
c ⁺⁴	12.0088	3,583,375	3
c ⁺⁵	12.0083	12,625,199	3
c ⁺⁶	12.0077	23,924,616	3

The molar volume of solid SiC (\tilde{V}_{SiC} = 12.5 cc) was derived from a mean density of 3.21 gm/cc.

The volume coefficient of thermal expansion for silicon carbide is

$$\alpha_v = \frac{1}{v} \left[\frac{\partial v}{\partial T} \right]_p = 14.1 \times 10^{-6} \text{ cc/cc-deg.}$$

This value was derived from the linear coefficient of thermal expansion for silicon carbide given in Ref. 4 for the temperature range 20-800°C.

Two values of the gas constant were used: R = 1.98716 cal/deg- mole and R = 82.0557 cc-atm/deg-mole. Their ratio gives the conversion factor c = 0.0242172.

V. COMPUTATIONAL PROCEDURE

The two sets of equilibrium composition equations—the one involving condensed SiC and the other the gaseous species only—represent two mutually exclusive contiguous regions. It is expedient to determine the border line between the two regions, that is, the conditions of temperature and pressure under which the condensed species just vanishes. This can be done in the following manner.

Since $n_{\underline{SiC}} = 0$ along the gas/condensate interface, it follows that Eqs. (5) and (12) are identical for this condition. Hence, for a particular species, say SiC (g), combining Eqs. (5) and (12) gives the relation

$$n_{Si}n_{C}(P/n)^{2} = (K_{SiC}^{6}/K_{SiC}^{1}) \exp \left[(P-1)\vec{v}_{\underline{SiC}}/RT \right],$$
 (28)

where the equilibrium constants $K_{\rm SiC}^1$ and $K_{\rm SiC}^6$ are computed on the basis of Eqs. (1) and (6), respectively. Now, if each side of Eq. (28) is plotted against pressure for an arbitrary temperature, the result is a graph of two curves that intersact at a unique pressure.

VI. RESULTS

The results of this study are presented numerically in Tables 1 and 2 and graphically in Figs. 1 through 4. Figure 1--as well as its detail, Fig. 2--is a conventional Mollier diagram for silicon carbide; specific enthalpy is plotted against specific entropy, with cross plots of temperature, pressure, and molecular weight in the pure gas region, and cross plots of temperature and moles of condensed SiC in the gas-solid region. The broken line demarcates the pure gas phase (above) from the smoke (below). The absence of a discontinuity at 3259° K (the temperature at which β -SiC is supposed to decompose at 1 atm) is due to the lack of experimental data concerning the solubility of graphite in liquid silicon at and above this temperature.

Figure 3 is a plot of volume versus temperature with cross plots of constant pressure and moles of condensed SiC.

The variation of sublimation temperature with pressure for silicon carbide and graphite is shown in Fig. 4. For silicon carbide at 10^{-3} atm the sublimation temperature is 2483° K, at 1 atm it is 3259° K, while at 10^{2} atm it is 4096° K. The corresponding temperatures for graphite are 3150° K, 4127° K, and 5170° K, respectively. (5)

All the computations required to obtain the results in Tables 1 and 2 were made on the RAND IEM 7040/7044 computer. In the tables the numbers are represented in "floating decimal" notation; the first five digits indicate the decimal form of the number, and the last two digits indicate a power of 10. Thus, 12345 05 represents 0.12345×10^5 and 12345-05 represents 0.12345×10^{-5} .

SUMMARY OF COMPUTED VALUES OF VOLUME, MOLECULAR WEIGHT, MOLES OF GAS, AND MOLES OF SOLID SIC FOR SILICON CARBIDE AT VARIOUS TEMPERATURES AND PRESSURES

Tempera- ture T (^O K)	Pressure, P (atm)	Log Volume, v (cc/gm)	Molecular Weight, M	Moles of Gas,	Moles of
000 04	10000-07	12565 02	13403 02	29916 01	
C00 04	10000-06	11555 02	13707 02	29252 01	
CC0 04	10000-05	10508 02	15289 02	59552 01	
CC0 04	10000-04	94425 01	17771 02	22563 01	
000 04	10000-03	84085 01	19218 02	20864 01	
000 04	10000-02	73962 01	19774 02	20278 01	
CCO 04	1000-01	63920 01	19963 02	20085 01	
OCO 04	1CCCC CC	53901 01	20050 02	19998 01	
C00 04	10000 01	43841 01	20333 02	19720 01	
C00 04	10000 02	33370 01	22658 02		
CCO 04	1CCCC C3	21832 01	32293 02		
000 04	1CCCC 04	10454 01	44348 02	90414 00	
500 04	10000-07	12519 02	13674 02	29323 01	
5CO 04	1CCCC-06	11473 02	15172 02	26429 01	
500 04	10000-05	10407 02	17668 02	22694 01	
500 04	10000-04	93718 01	19174 02	20912 01	
500 04	10000-03	83587 01	19758 02	20294 01	
500 04	10000-02	73544 01	19956 02	20092 01	
500 04	10000-01	63528 01	20028 02	20021 01	
500 04	10000 OC	53507 01	20126 02	19923 01	
>00 04	10000 01	43342 01	20905 02	19180 01	
500 04	ICOCC C2	32335 01	26363 02	15210 01	
500 04	ICCCC 03	20774 01	37766 C2	10617 01	
500 04	10000 04	97013 00	48343 02	82942 00	
CCO 04	10000-C7	12423 02	15500 02	25858 01	
C00 04	10000-06	11359 02	17943 02	22347 01	
CCO 04	10000-05	10328 02	19291 02	20786 01	
CCO 04	10000-04	93164 01	19799 02	20252 01	
CCC 04	10000-03	83127 01	19969 02	20080 01	
C00 04	10000-02	73115 01	20026 02	20022 01	
CCO 04	10006-01	631C5 01	20073 02	19976 01	
000 04	1CCCO CO	53040 01	20372 02	19682 01	
CCO 04	10000 01	42494 01	23106 02	17354 01	
CCO 04	1000C 02	30968 01	32828 02	12214 01	
CCO C4	1CCCC C3	19861 01	42947 02	93363 00	

Table 1 -- continued

Tempera- ture, T (K)	Pressure, P (atm)	Log Volume, v (cc/gm)	Molecular Weight, M	Moles of Gas,	Moles of SiC
5000 04	10000 04	89569 CC	52166 02	76864 00	
5000 04	30044 04	39355 00	55179.02	72668 00	-55879-08
5000 04	30044 04	35383 00	53179 02	65401 00	10000 00
5CCO 04	30044 04	31010 00	51318 02	58134 00	20000 00
5000 04	30044 04	26148 00	49584 02	50867 00	30000 00
5000 04	30044 04	20672 00	47963 02	43601 00	40000 00
5000 04	30044 04	14404 00	46444 02	36334 00	50000 00
5000 04 5000 04	30044 04 30044 04	70765-01	45019 02 43679 02	29067 00 21800 00	60000 00 70000 00
5000 04 5000 04	30044 04 30044 04	-12823 CO	42416 02	14534 00	80000 00
5000 04	30044 04	-27734 00	41224 02	72668-01	90000 00
5CQO 04	3C044 C4	-47710 00	40207 02	72668-02	99000 00
5000 04		-50323 00	40108 02	72668-03	99900 00
5C00 04	3CC44 C4	-50593 OC	40098 02	72668-04	99990 00
5000 04	30044 04	-50620 00	40097 02	72668-05	99999 00
4500 04	10000-07	12298 02	18586 02	21574 01	
4500 04	1000-06	11276 02	19545 02	20515 01	
45C0 C4	10000-05	1C594 05	19885 02	20164 01	
4500 04	10000-04	92664 01	19997 02	20052 01	
4500 04	10000-03	82656 01	20034 02	20015 01	
4500 04	10000-05	72650 01	20059 02	19989 01	
45CO 04	10000-01	62617 01	20211 02	19840 01	
4500 04 4500 04	10000 00	52294 01 40937 01	21773 02 29762 02	18416 OI 13473 OI	
4500 04	10000 02	29729 01	39307 02	10201 01	
4500 04	10000 02	16845 01	48170 02	83240 00	
4500 04	51832 03	11209 01	53933 02	74346 00	-97789-08
4500 04	51832 03	10762 01	52134 02	66912 00	10000 00
4500 04	51832 03	10265 01	50451 02	59477 00	20000 00
4500 04	51832 03	97034 CO	48874 02	52042 00	30000 00
4500 04	51832 03	90580 00	47392 02	44608 00	40000 00
45CO 04	51832 C3	82997 CO	45997 02	37173 00	50000 00
4500 04	5/832 03	73804 OC	44682 02	29739 00	60000 00
4500 04	51832 03	62127 GC	43440 02	22304 00	70000 00
4500 04	51832 03	46107 00	42266 02	14869 00	80000 00
4500 04	51832 03	2C451 CC	41153 02	74346-01	90000 00
4500 04	51832 C3	-35586 00	40200 02	74346-02	99000 00
4500 04	51832 03	-48863 CO	40107 02	74346-03	59900 00
4500 04	51832 03	-50444 00	40098 02	74346-04	99990 00
4500 04	51832 03	-50605 CC	40097 02	74346-05	99999 00

Table 1--continued

Tempera- ture,	Pressure,	Log Volume,	Molecular Weight,	Moles of Gas,	Moles of
T (OK)	P (atm)	v (cc/gm)	<u> </u>	'n	SIC
4000 04	10000-07	12219 02	19820 02	20231 01	
4000 04	10000-C6	11216 02	19975 02	20073 01	
40C0 04	10000-05	10215 02	20025 02	20023 01	
4000 04	10000-04	92142 01	20042 02	20006 01	
4000 04	10000-03	82139 01	20058 02	19990 01	
4000 04	10000-02	72114 01	20173 02	19877 01	
4000 04	10000-01	61840 01	21486 02	18662 01	
4000 04 4000 04	10000 00	50549 01	28926 02	13862 01	
	10000 01	3938C 01	37863 02	10590 01	
4000 04	10000 02	28624 01	45054 02	88997 00	
4CCO 04	64751 02	19870 01	52230 02	76771 00	-12340-07
4000 04	64751 02 64751 02	19414 01	50696 02	69094 00	10000 00
4000 04	_	18904 01	49249 02	61416 00	20000 00
4000 04	64751 02 64751 02	18327 01 17661 01	47883 02	53739 00	30000 00
4000 04	64751 C2	17661 01 16874 01	46591 02	46062 00	40000 00
40CO 04	64751 02	15912 01	45366 02	38385 00	50000 00
4CCO 04	64751 C2	14674 01	44205 02 43101 02	30708 00	60000 00
4000 04	64751 02	12936 0i	43101 02 42051 02	23031 00	70000 00
4CCO 04	64751 02	99938 00	41051 02	15354 00 76771-01	80000 00
4000 04	64751 02	10691 00	40191 02	76771-02	90000 00 99000 00
4000 04		-3888> 00	40106 02	76771-02	
4000 04		-49296 00	40098 02	76771-04	99900 00 99990 00
4CCO 04		-5C489 CC	40097 02	76771-05	99999 00
		201111	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	10111-07	77777 00
35CO 04	1CCCC-C7	12157 02	20029 02	20019 01	
3500 04	10000-06	11156 02	20043 02	20006 01	
35CO 04	10000-05	10156 02	20048 02	20000 01	
35CO 04	10000-04	91558 01	20064 02	19984 01	
35CO 04	10000-03	81522 01	20228 02	19822 01	
3500 04	10000-02	71084 01	22374 02	17922 01	
35CO 04	10000-01	597C1 01	30768 CZ	13032 01	
35CO U4	icccc cc	48752 01	38278 02	10475 01	
3500 04	10000 01	38162 01	43849 02	91443 00	
35CO 04	46702 01	30929 01	49649 C2	80761 00	-73342-08
3500 04	46702 01	30472 01	48494 02	72685 00	10000 00
35CO 04	46702 01	2996C 01	47391 02	64609 OU	20000 00
3500 04	46702 01	29381 01	46338 02	56533 00	30000 00
3500 04	46702 01	28712 C1	45330 02	43457 00	40000 00
3500 04	46702 01	27920 01	44365 02	40381 00	50000 00
35CO 04	46702 CL	26952 01	43440 02	32304 00	60000 00
3500 04	46702 CL	257C3 C1	42553 02	24228 00	70000 00

Table 1 -- continued

Tempera-	_	Log	Molecular	Moles of	
ture,	Pressure,	Volume,	Weight,	Gas,	Moles of
T (°K)	P (atm)	v (cc/gos)	<u> </u>	n	<u>S1C</u>
3500 04	46702 Cl	23944 01	41702 02	16152 00	80000 00
3500 04	46702 01	20939 01	40884 02	80761-01	90000 00
3500 04	46702 01	11036 01	40174 02	80761-02	99000 00
3500 04	46702 01	19033 00	40105 02	80761-03	99900 00
3500 04	46702 01	-36096 00	40098 02	80761-04	99990 00
3500 04	46702 01	-48932 00	40097 02	80761-05	99999 00
3259 04	99866 00	37461 01	48051 02	83447 00	-25029-08
3259 04	99866 00	37003 01	47116 02	75102 00	10000 00
3259 04	99866 CC	36492 01	46217 02	66758 00	20000 00
3259 04	99866 00	35912 01	45352 02	58413 00	30000 00
3259 04	99866 00	35242 01	44519 02	50068 00	40000 00
3259 04	99866 00	34451 01	43715 02	41724 00	50000 00 60000 00
3259 04	99866 GC	33482 01	42940 02	33379 00	60000 00 70000 00
3259 04	99866 CO	32233 01	42192 02	25034 00 16689 00	80000 00
3259 04	99866 CO	30472 01	41470 02 40772 02	83447-01	90000 00
3259 04	99866 CC	27463 01	40164 02	83447-02	99000 00
3259 04	99866 CC	17485 01 76969 00	40104 02	83447-03	99900 00
3259 04	99866 0C 99866 00	-60995-01	40098 02	83447-04	99990 00
3259 04 3259 04	99866 CC	-43481 00	40097 02	83447-05	99999 00
3000 04	10000-07	12089 02	20048 02	20000 01	
3000 04	10000-06	11089 02	20054 02	19995 01	
3000 04	10000-05	10088 02	20105 02	19943 01	
3000 04	10000-04	90706 01	20925 02	19162 01	
3000 04	10000-03	79586 01	27078 02	14808 01	
3000 04	10000-02	68452 01	35158 02	11405 01	
3C00 04	10000-01	57909 01	39846 02	10063 01	
3000 04	10000 00	47399 01	44808 02	89487 00	
3000 04	14625 CC	45619 01	46156 02	86873 00	
3000 04	14625 00	45162 01	45469 02	78186 00	
3000 04	14625 00		44802 02	69498 00	
3CC0 04	14625 CC	44070 01	44155 02	60811 00	
3000 04	14625 00		43525 02	52124 00	
3000 04	14625 00		42914 02	43436 00 34749 00	
3000 04	14625 CO		42319 02		
3000 04	14625 OC		41741 02 41178 02	26062 00 17375 00	
3000 04	14625 00		40631 02	86873-01	
3000 04	14625 CO		40150 02	86873-02	
3000 04	14625 CO		40102 02	86873-03	
3000 04 3000 04	14625 CC		40098 02	86873-04	
4111111 114	14027 00	・ ファィフラ じし	70070 UE	35513 64	

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Table 1 -- continued

Tempera-	Pressure,	Log Volume,	Molecular Weight,	Moles of Gas,	Moles of
T (OK)	P (atm)	v (cc/gm)	H	n 	Sic
25CO 04	10000-07	12008 02	20143 02	19906 UL	
2500 04	10000-06	10968 02	22064 02	18173 01	
2500 04	1COCC-05	98487 01	29063 02	13796 01	
2500 04	10000-04	87606 01	35598 02	11264 01	
25C0 04	1CC00-03	77160 01	39451 02	10164 01	
25CO 04	1000-02	66864 01	42230 02	94950 00	
2500 04	12127-02	65985 01	42636 02	94044 00	-14584-0
2500 04	12127-02	65527 01	42368 02	84640 00	10000 0
2500 04	12127-02	65016 01	42103 02	75235 00	20000 0
25CO 04	12127-02	64436 01	41842 02	65831 00	30000 0
2500 04	12127-02	63767 01	41583 02	56427 00	40000 0
2500 04	12127-02	62975 01	41328 02	47022 00	50000 0
25CO 04	12127-02	62006 01	41076 02	37618 00	60000 0
25C0 04	12127-02	60756 01	40827 C2	28213 00	70000 0
2500 04	12127-02	58995 01	40581 02	18809 00	80000 0
2500 04	12127-02	55985 01	40337 02	94044-01	90000 0
2500 04	12127-02	45985 01	40121 02	94044-02	99000 0
2500 04	12127-02	35985 01	40100 02	94044-03	99900 0
2500 04	12127-02	25988 01	40097 02	94044-04	99990 0
2500 04	12127-02	16019 01	40097 02	94044-05	99999 0
2200 04	24596-04	82513 01	41150 02	97442 00	-10746-0
2200 04	24596-04	82055 01	41042 02	87698 00	10000 0
2200 04	24596-04	81544 01	40935 02	77954 00	20000 0
2200 04	24596-04	80964 01	40828 02	68210 00	30000 0
2200 04	24596-04	8C295 OL	40722 02	58465 00	40000 0
2200 04	24596-C4	79503 01	40617 02	48721 00	50000 O
2200 04	24596-04	78534 01	40512 02	38977 00	60000 0
2200 04	24596-C4	77284 01	40407 02	29233 00	70000 0
2200 04	24596-04	75523 01	40303 02	19488 00	80000 0
2200 04	24596-04	72513 01	40200 02	97442-01	90000 0
2200 04	24596-04	62513 01	40107 02	97442-02	99000 0
200 04	24596-04	52513 01	40098 02	97442-03	99900 0
2200 04	24596-04	42513 01	40097 02	97442-04	99990 0
200 04	24596-04	32514 01	40097 02	97442-05	99999 0
200 04	1CCG0-C7	11663 02	35623 02	11256 01	
2CCO 04	10000-06	10623 02	39137 02	10245 01	
200 04	95826-06	96259 01	40526 02	98942 00	-16809-0
2000 04	95826-06	95802 01	40483 02	89048 00	10000 0
2000 04	95826-06	9529C 01	40439 02	79153 00	20000 0
2000 04	95826-06	94710 Cl	40396 02	69259 00	30000 O
2000 04	95826-06	94041 01	40353 02	59365 00	40000 0

Table 1--continued

Tempe tur T (Pressure, P (atm)	Log Volume v (cc/g		Molecu Weigh M		Moles Gas n		Moles Sic	
2000	04	95826-06	93249	01	40310	02	49471	00	50000	υQ
2000	04	95826-06	9228C	01	40268	02	39577	00	60000	00
2000	04	95826-06	9103C	01	40225	02	29683	00	70000	00
2000	04	95826-06	89270	01	40182	02	19788	00	80000	00
2000	04	95826-06	86259	01	40140	02	98942	-01	90000	00
20C0	04	95826-C6	76259	01	40101	02	98942	-02	99000	00
2000	04	95826-06	66259	01	40098	02	98942	-03	99900	00
2000	04	95826-06	56259	01	40097	02	98942		99990	90
2000	04	95826-06	46259	01	40097	02	98942	-05	99999	00
1700	04	17355-08	12303	02	40023	02	10019	01	55760-	-08
1700	04	17355-C8	12257	02	40030	02	90167	00	10000	00
1700	04	17355-08	12206	02	40038	02	80148	00	20000	00
1700	04	17355-08	12148	02	40045	02	70130	00	3C000	00
1700	04	17355-08	12081	02	40053	02	60111	00	40000	00
1700	04	17355-08	12002	02	40060	02	50093	00	50000	00
1700	04	17355-08	11905	0.5	40067	02	40074	00	60000	00
1700	04	17355-C8	11780	02	40075	02	30056	00	70000	00
1700	04	17355-08	11604	02	40082	02	20037	00	80000	00
1700	04	17355-08	11303	C 2	40090	02	10018	00	90000	00
1700	04	17355-08	10303	02	40096	02	10019	-01	99000	00
1700	04	17355-CE	93028	01	40097	02	10019	-02	99900	00
1700	04	17355-C8	83028	01	40097	02	10019	-03	99990	00
1700	04	17355-08	73028	01	40097	02	10019	-04	99999	00
1774	04	10000-07	11560	02	40136	02	99928			
1882	04	1000C-06		02	40293	02	99531	00		
2002	04	10000-05		01	40532	02	9892A	CO		
2140	04	10000-04		01	40932	02	97957	00		
2299	04	10000-03		01	41573	02	96440	00		
2483 2698	04	10000-02 10000-01	668C4 57021	C1 01	42538	C2	94259	00		
2953	04 04	10000-01		01	43959	02 02	91213	00		
2973 3259	04	1CCCC CI		01	45810 48053	02	87529			
3632	04	10000 02		01	50430	02	83444	00		
30 <i>32</i> 4096	04	10000 02	18054	01	52611	C2	79510 76215	00		
4678	04	10000 04	-	00	54416	02	73687	00		

SUMMARY OF COMPUTED VALUES OF DENSITY, ENTHALPY, ENERGY, AND ENTROPY FOR SILICON CARBIDE AT VARIOUS TEMPERATURES AND PRESSURES

Table 2

Tempera-	_	Density,	Enthalpy,	Energy,	Entropy,	
ture,	Pressure, P (atm)	đ	h	u	s (cal/	
T ("K)		(gm/cc)	(cal/gm)	(cal/gm)	deg-gm)	
6CCO 04	1000 0- 07	27224-12	15612 05	14722 05	60744 01	
6CC0 04	1000-06	27841-11	15134 05	14264 05	56560 01	
6000 04	10000-05	31055-10	12956 05	12176 05	49737 01	
6CCC 04	1CCCC-C4	36096-09	10321 05	96500 04	42577 01	
6000 04	10000-03	39035-08	90984 04	84780 04	38078 01	
6CC0 04	10000-02	40164-07	86766 04	8C737 04	35034 01	
6C00 04	10000-01	40548-06	85393 04	79421 04	32504 01	
6CCC C4	1CCCC CC	40724-05	84865 04	78919 04	30129 01	
6CCO 04	10CCO C1	41299-04	83813 04	77949 04	27682 01	
6CCO 04	10000 C2	46022-03	76518 04	71256 04	24299 01	
6000 04	10000 03	65591-02	57415 04	53722 04	19390 01	
6CCO C4	10000 04	90077-01	46268 04	43579 04	16332 01	
55CO 04	1000-07	30299-12	14996 05	14196 05	59661 01	
5500 04	10000-06	33618-11	12929 05	12209 05	52694 01	
55CO 04	10000-05	39149-10	10263 05	96442 04	45058 01	
55CO 04	10000-04	42486-09	89903 04	84203 04	40273 01	
55CO 04	10000-03	43781-08	85487 04	79955 04	37126 01	
5500 04	10000-02	44219-07	84054 04	78577 04	34563 01	
55CC 04	1CCCC-C1	44377-06	83571 04	78113 04	32187 01	
55CO 04	10000 CC	44596-05	83149 04	77718 04	29830 01	
55CO 04	10000 C1	46321-04	8C461 C4	75233 04	27096 01	
5500 04	10000 02	58414-03	65831 04	61685 04	22432 01	
55CO 04	1CCCC C3	83680-02	49368 04	46474 04	17993 01	
55CO 04	10000 04	10712 00	42284 04	40024 04	15640 01	
5000 04	1CCGO-C7	37780-12	12359 05	11718 05	54591 01	
5CCO 04	10000-06	43733-11	98647 04	93110 04	46869 0	
5CCO 04	10000-05	47019-10	87583 04	82432 04	42210 01	
5CCO 04	1CCCC-04	48257-09	83804 04	78786 04	39119 0	
5000 04	10000-03	48671-08	82584 04	77608 04	36575 01	
5000 04	1CCCC-02	48811-07	82186 04	77224 04	34208 01	
5CCO 04	10000-01	48925-06	81959 04	77010 04	31880 0	
50CG 04	1CCCC OC	49654-05	80885 04	76008 04	29397 0	
5CCO 04	10000 01	56317-04	72261 04	67961 04	25521 01	
5CCC 04	TCCCC 05	8C015-U3	531C4 04	50077 04	20009 01	
5CCO 04	1CCCO 03	10468-Cl	43477 04	41164 04	16873 01	

Table 2 -- continued

Tempera- ture,	Pressure.	Density,	Enthalpy,	Energy,	Entropy, s (cal/	
T (OK)	P (atm)	(gm/cc)	(cal/gm)	(cal/gm)	deg-gm)	
5CCO 04	1000 04	12715 CO	38835 C4	36931 04	14983 01	
5000 04	30044 G4	40407 00	37654 04	35853 04	14340 01	
5CCO 04	3C044 C4	44277 00	34984 04	33341 04	13406 01	
5000 04	30044 04	48966 OC	32315 04	30830 04	13272 01	
5CCO 04	30044 C4	54767 CC	29646 04	28318 04	12739 01	
5000 04	30044 04	62127 CO	26977 04	25806 04	12205 01	
5000 04	3C044 C4	71773 CC	24308 04	23295 04	11671 01	
5000 04	3C044 04	84964 CO	21639 04	20783 04	11137 01	
5000 04	3C044 04	10410 01	18970 04	18271 04	10603 01	
5000 04	30044 04	13435 01	16301 04	15760 04	10070 01	
5000 04	30044 04	18938 Cl	13632 04	1324A 04	95357 00	
5C00 04	30044 04	29998 01	11230 04	10987 04	90553 00	
5CCO 04	30044 04	31859 01	10990 04	10761 04	90073 00	
5000 04	30044 04	32058 01	10966 04	10739 04	90025 00	
5CCO 04	30044 04	32078 CL	10963 04	10737 04	90020 00	
45CO 04	1000-07	50335-12	91710 04	86899 04	47913 01	
45CO 04	10000-06	52933-11	84268 04	79693 04	43868 01	
4500 04	10000-05	53853-10	81805 04	77308 04	41004 UI	
4500 04	1CCC0-04	54154-09	81016 04	76544 04	38535 01	
45CO 04	1CCCC-C3	54255-08	80760 04	76296 04	36192 01	
4500 04	10000-02	54324-07	80629 04	76171 04 75653 04	33880 01	
4500 04 4500 04	10000-01 10000 00	54734-06 58966-05	80077 04 74787 04	75653 04 70680 04	31492 01 28097 01	
4500 04	10000 00	80601-04	56045 04	53040 04	22097 01	
4500 04	10000 02	10645-02	44298 04	42023 04	18163 01	
4500 04	10000 03	13045-01	38867 04	37011 04	15903 01	
4500 04	51832 03	75706-01	36445 04	34787 04	14726 01	
45CO 04	51832 03	83898-C1	33708 04	32212 04	14117 01	
4500 04	51832 03	94078-01	30971 04	29637 04	13509 01	
4500 04	51832 03	10707 00	28234 04	27062 04	12901 01	
4500 04	51832 03	12422 00	25497 04	24487 04	12293 01	
4500 C4	51832 C3	14792 CC	22761 04	21912 04	11685 01	
4500 04	51832 C3	18280 CO	20024 04	19337 04	11076 01	
4500 04	51832 03	23918 CO	17287 04	16762 04	10468 01	
4500 04	51832 03	34588 CO	14550 04	14187 04	98601 00	
4500 04	51832 03	62444 CO	11813 04	11612 04	92519 00	
4500 04	51832 03	22692 01	93501 03	92948 03	87045 00	
4500 04	51832 03	30805 01	91038 03	90630 03	86498 00	
45CC 04	51832 03	31948 01	90791 03	90399 03	86443 00	
45CO C4	51832 C3	32067 Cl	90767 03	90375 03	86438 00	

Table 2--continued

Tempera- ture,	Pressure,	Density,	Enthalpy,	Energy,	Entropy,
T (OK)	P (atm)	(gon/cc)	(cal/gm)	(cal/gm)	deg-gm)
4CCC C4	10000-07	6C3P5-12	80899 04	76889 04	45400 01
4000 04	10000-06	6C859-11	79801 04	75822 04	42827 01
4000 04	10000-05	61012-10	79452 04	75483 04	40453 01
4000 04	10000-C4	61063-09	79337 C4	75371 04	38140 01
4CCO 04	1CCC0-03	61112-08	79263 04	75301 04	35840 01
4000 04	10000-03	61460-07	78847 04	74907 04	33459 01
4000 04	10000-01	65462-06	74292 04	70592 04	30096 01
4000 04	10000 CC	e8130-05	55888 04	53140 04	23620 01
4000 04	1000C 01	11536-03	43838 04	41739 04	19242 01
4CCO 04	10000 02	13727-02	38743 04	36978 04	16857 01
4000 04	64751 02	10304-01	35456 04	33934 04	15272 01
4000 04	64751 02	11445-01	32645 C4	31274 04	14569 01
4000 04	64751 02	12869-01	29833 04	28615 04	13866 01
4CCO 04	64751 02	1469901	27022 04	25955 04	13163 01
4000 04	64751 C2	17136-01	24210 04	23295 04	12460 01
4C00 04	64751 C2	20542-01	21399 04	20636 04	11757 01
ACCO C4	64751 02	25636-01	18588 Q4	17976 04	11055 01
4000 04	64751 02	34090-01	15776 04	15316 04	10352 01
4CCO 04	64751 02	50865-01	12965 04	12657 04	96489 00
4000 04	64751 C2	10014 00	10153 04	99968 03	89460 00
4000 04	64751 CZ	78178 CO	76231 03	76031 03	83134 00
4000 04	64751 C2	24482 01	73701 03	73637 03	82502 00
4CCO 04	64751 G2	31114 01	73448 03	73397 03	82439 00
4000 04	64751 02	31981 01	73423 03	73373 03	82432 00
3500 04	1CC0C-07	69742-12	78073 04	74601 04	44654 0
35CO 04	10000-06	69788-11	77983 04	74512 04	42344 0
3500 04	10000-05	69807-10	77949 04	74480 04	40052 0
35CO C4	1C00C-04	69863-09	77887 04	74420 04	37753 0
35CO 04	1CC00-C3	70434-08	77291 04	73853 04	35308 0
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3500 04	10000 01	15268-03	37811 04	36225 04	17639 0
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35CC 04	46702 C1	89704-03	32015 04	30754 04	15325 0
3500 04 3500 04	46702 01 46702 01	10091-02 11533-02	29085 04	27964 04	14488 0
35CC 04 35CO 04	46702 C1 46702 C1	13454-02	26155 04 23226 04	25175 04 22385 04	13651 0 12814 0
3500 G4	467C2 C1	16143-02	20296 04	19596 04	
3500 04	46702 01	20176-02	17367 04	16806 04	11977 0
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3500 U4	46702 C1	26846-02	14437 04	14017 04	10303

Table 2--continued

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3500 C4 46702 C1 8C554-C2 85783 03 84379 03 86291 03 3500 04 46702 C1 78774-01 59417 03 59274 03 78758 03 3500 04 46702 C1 64516 0C 56781 C3 56763 03 78004 04 3500 04 46702 C1 22959 01 56517 03 56512 03 77929 03 3500 04 46702 C1 3C854 01 56491 03 56487 03 77929 03 3500 04 46702 C1 3C854 01 56491 03 56487 03 77922 03 3259 04 99866 CC 17944-03 34937 04 33589 04 16788 03 3259 04 99866 CC 22430-03 28917 04 27839 04 14941 03 3259 04 99866 CC 22430-03 28917 04 27839 04 14941 03 3259 04 99866 CC 25634-03 25908 04 24964 04 14017 03 3259 04 99866 CC 35887-03 19888 04 19214 04 12170 03 3259 04 99866 CC 35887-03 19888 04 19214 04 12170 03 3259 04 99866 CC 48857-03 16879 04 16339 04 11247 04 3259 04 99866 CC 59807-03 13869 04 13465 04 10323 03 3259 04 99866 CC 89701-03 10859 04 10590 04 93997 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78495 03 77146 03 84762 03 3259 04 99866 CC 17935-02 78490 03 48684 03 75619 03 3259 04 99866 CC 17935-02 78490 03 48684 03 75619 03 3259 04 99866 CC 17935-02 78490 03 48684 03 75619 03 3000 04 10000-03 11000-07 56360 04 54604 04 5019 03 5000 04 10000-03 11000-07 56360 04 54604 04 5019 03 5000 04 14625 CC 34270-04 22654 04 21899 04 15679 04 15679 04 15679 04 15679 04 15679 0						
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3COO 04 14625 CO 27421-U4 35105 04 33814 04 17653 (3COO 04 14625 CO 3C468-04 31992 04 30830 04 16615 (3CCO 04 14625 CC 34277-04 2E880 04 27846 04 15578 (3CCO 04 14625 CO 39173-04 25767 04 24862 04 14540 (3CCO 04 14625 CO 45702-04 22654 04 21879 04 13502 (3CCO 04 14625 CC 54842-04 19541 04 18895 04 12465 (3CCO 04 14625 CC 68552-C4 16428 04 15911 04 11427 (3CCO 04 14625 CC 68552-C4 16428 04 15911 04 11427 (3CCO 04 14625 CC 91403-C4 13315 04 12927 04 10390 (3CCO 04 14625 CC 13710-03 10202 04 99436 03 93519 (3CCO 04 14625 CC 27419-03 70890 03 69598 03 83142 (3CCO 04 14625 CC 27398-C2 42873 C3 42744 03 73803 (3CCO 04 14625 CC 27189-C1 40072 03 40059 03 72870 (3CCO 04 14625 OC 27189-C1 40072 03 40059 03 72870 (3CCO U4	10000-01		38942 04	37446 04	50140 01
3000 04 14625 00 3C468-04 31992 04 30830 04 16615 03000 04 14625 00 34277-04 2E880 04 27846 04 15578 03000 04 14625 00 39173-04 25767 04 24862 04 14540 03000 04 14625 00 45702-04 22654 04 21879 04 13502 0300 04 14625 00 54842-04 19541 04 18895 04 12465 0300 04 14625 00 68552-04 16428 04 15911 04 11427 03000 04 14625 00 91403-04 13315 04 12927 04 10390 03000 04 14625 00 13710-03 10202 04 99436 03 93519 03000 04 14625 00 27419-03 70890 03 69598 03 83142 0300 04 14625 00 27419-03 70890 03 69598 03 83142 03000 04 14625 00 27398-02 42873 03 42744 03 73803 03000 04 14625 00 27189-01 40072 03 40059 03 72870 03000 04 14625 00 25262 00 39791 03 39790 03 72776 03000 04 14625 00 25262 00 39791 03 39790 03 72776 03000 04 14625 00 25262 00 39791 03 39790 03 72776 030000 04 14625 00 25262 00 39791 03 39790 03 72776 03000 04 14625 00 25262 00 39791 03 39790 03 72776 03000 04 14625 00 25262 00 39791 03 39790 03 72776 030000 04 14625 00 25262 00 39791 03 39790 03 72776 030000 04 14625 00 25262 00 39791 03 39790 03 72776 030000 04 14625 00 25262 00 39791 03 39790 03 72776 030000 04 14625 00 25262 00 39791 03 39790 03 72776 030000 04 14625 00 25262 00 39791 03 39790 03 72776 030000 04 14625 00 25262 00 39791 03 39790 03 72776 030000 04 14625 00 25262 00 39791 03 39790 03 72776 0300000 04 14625 00 25262 00 39791 03 39790 03 72776 030000000000000000000000000000000000						• • • • •
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होता जिल्लाक के क्षेत्र की कारण का प्रथमिताला है।

Table 2--continued

Tempera- ture, T (K)	Pressure, P (atm)	Density, d (gm/cc)	Enthalpy, h (cal/gm)	Energy, u (cal/gm)	Entropy, s (cal/ deg-gm)	
25CO 04	10000-07	861 63-15	74942 04	72476 04	43588 01	
25CO 04	10000-06	10756-10	69100 04	65848 04	38639 01	
2500 04	10000-05	14168-09	50870 04	49161 04	29935 01	
2500 04	1CCC0-04	17353-08	41610 04	40215 04	24817 01	
25CO 04	1CCOC-03	19231-07	37863 04	36604 04	22106 01	
25CC 04	10000-02	20586-06	35925 04	34749 04	20205 01	
25CO 04	12127-02	25205-06	35679 04	34514 04	20017 01	
2500 04	12127-02	280C6-06	32344 04	31295 04	18682 01	
25CO 04	12127-02	315C7-06	29008 04	2807€ 04	17348 01	
25CO 04	12127-02	36008-06	25673 04	24857 04	16014 01	
25CO 04	17127-02	42009-06	22337 04	21638 04	14680 01	
2500 04	12127-02	50411-06	19002 04	18419 04	13346 01	
2500 04	12127-02	63014-06	15667 04	15200 04	12011 01	
2500 04	12127-02	84018-06	12331 04	11982 04	10677 01	
2500 04	12127-02	12603-05	89957 03	87626 03	93431 00	
2500 04	12127-02	25205-05	56602 03	55437 03	80090 00	
25CC 04	12127-02	252C5-04	26583 03	26467 03	68082 00	
2500 04	12127-02	25204-03	23581 03	23570 03	66881 00	
2500 04	12127-02	25186-02	23281 03	23280 03	66761 00	
2500 04	12127-02	25009-01	23251 03	23251 03	66749 00	
2200 04	24596-04	56066-08	35828 04	34766 04	21931 01	
2200 04	24596-04	62296-08	32380 04	31424 04	20364 01	
22C0 04	24596-04	70082-08	28932 04	28082 04	18797 01	
22C0 G4	24596-04	80094-08	25484 04	24740 04	17229 01	
2200 04	24596-04	93443-08	22036 04	21398 04	15662 01	
2200 04	24596-04	11213-07	18588 04	18057 04	14095 01	
2200 04	24596-04	14016-07	15140 04	14715 04	12528 01	
22C0 04	24596-04	18689-07	11692 04	11373 04	10960 01	
2200 04	24596-04	28033-07	82436 03	80311 03	93929 00	
2200 04	24596-04	56066-07	47955 03	46892 03	78256 00	
2200 04	24596-04	56066-06	16922 03	16816 03	64150 00	
2200 04	24596-04	56066-05	13819 C3	13808 03	62740 00	
2200 04	24596-04	56065-04	13509 03	13507 03	62599 00	
2200 04	24596-04	56056-03	13477 03	13477 03	62585 00	
2000 04	10000-07	21707-11	40186 04	39071 04	28036 01	
2000 04	10000-06	23848-10	36819 04	35804 04	25136 01	
2000 04	95826-06	23664-09	35733 04	34753 04	23466 01	
2000 04	95826-C6	26293-09	32230 04	31346 04	21715 01	
2000 04	95826-06	29579-09	28727 04	27943 04	19963 01	
2000 04	95826-06	33805-09	25224 04	24538 04	18212 01	
2000 04	95826-06	39439-09	21721 04	21133 04	16460 01	

Table 2--continued

Tempera-	December	Density,	Enthal	рy,	Energ	y,	Entro	
ture, T (^o K)	Pressure, P (atm)	(gm/cc)	h (cal/g	m)	u (cal/	gna)	s (ca deg-g	
						<u> </u>		
2000 04	95826-C6	47327-09		C4	17728	04	14709	
2000 04	95826-C6	59159-09		04	14323	04	12957	01
2000 04	95826-C6	78878-C9		04	10918	04	11206	01
2000 04	95826-06	11832-08		03	75129	03	94541	00
2000 04	95826-06	23664-08		03	41080	03	77026	00
20CO G4	95826-06	23664-07		03	10435	03	61262	00
2000 04	95826-06	23664-06		02	73702	02	59686	00
2000 04	95826-06	23663-05		02	70637	02	59528	00
2000 04	9582606	23663-04	70332	02	70331	02	59512	00
17CO 04	17355-08	49793-12	35338	04	34494	04	26369	01
1700 04	17355-08	55326-12	31779	04	31019	04	24275	01
1700 04	17355-08	62241-12	28220	04	27545	04	22182	01
1700 04	17355-08	71133-12	24661	04	24070	04	20089	0.1
1700 04	17355-08	82989-12		04	20596	04	17995	0
1700 04	17355-08	99586-12	17543	04	17121	04	15902	0
1700 04	17355-08	12448-11	13985	04	13647	04	13808	0
1700 04	17355-08	16598-11	10426	04	10173	04	11715	0
1700 04	17355-08	24897-11	68669	03	66981	03	96214	00
1700 04	17355-08	49793-11	33081	03	32237	03	7528C	0(
1700 04	17355-08	49793-10	10517	02	96727	01	56439	0(
1700 04	17355-08	49793-09	-21513	02	-21597	02	54555	0(
1700 04	17355-C8	49793-08	-24716	02	-24724	02	54366	0
1700 04	17355-08	49793-07	-25036	02	-25037	02	54348	00
								_
1774 04	LCCCC-C7	27569-11	35448	04	34570	04	25570	0
1882 04	1CCCO-06	26102-10	3560l	04	34674	04	24513	0
2002 04	1000-05	24669-09		04	34754	04	23446	0
2140 04	1 C C O C - O 4	23303-08	35817	04	34778	04	22361	0
2299 04	10000-03	22034-07	35807	04	34709	04	21248	0
2483 04	10000-02	20875-06	35693	04	34533	04	20113	0
2698 04	10000-01	198>4-05	35438	04	34219	04	18957	0
2953 04	1CCCC CC	18904-04	35149	04	33869	04	17832	0
3259 04	10000 01	17968-03	34937	04	33588	04	16787	0
3632 04	10000 02	16920-02	35019	04	33587	04	15880	0
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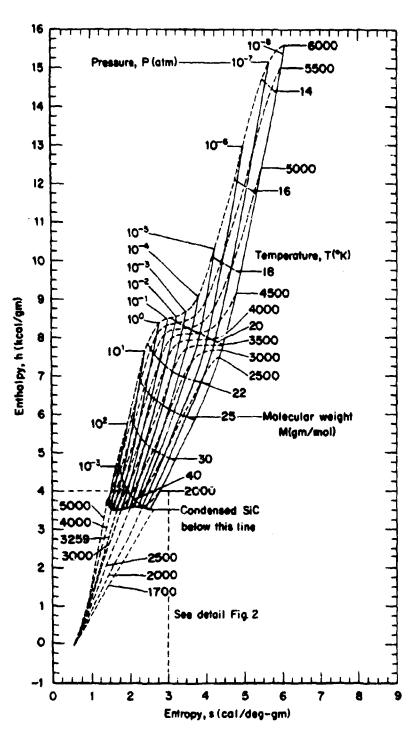


Fig. 1— Enthalpy versus entropy for silicon carbide with cross plots of temperature, pressure, molecular weight, and moles of condensed SiC

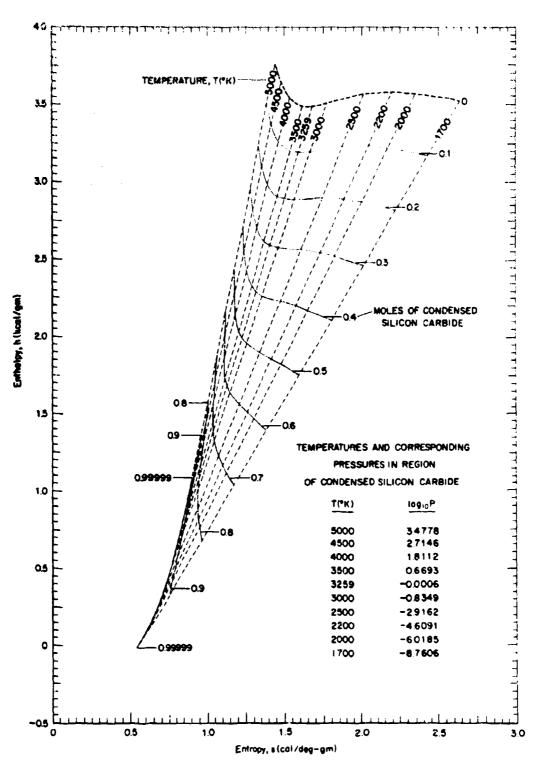


Fig. 2 - Detail of Fig. 1 showing fine structure in area of condensed SiC

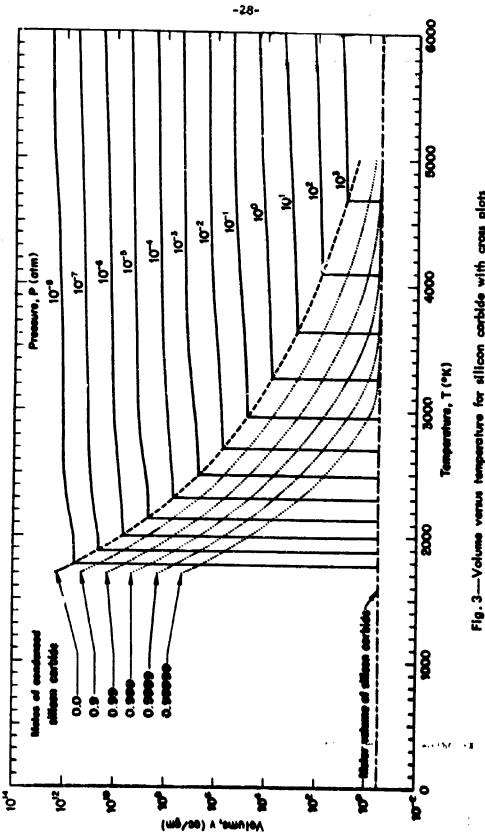


Fig. 3—Volume versus temperature for silicon carbide with cross plots of constant pressure and moles of condensed SIC

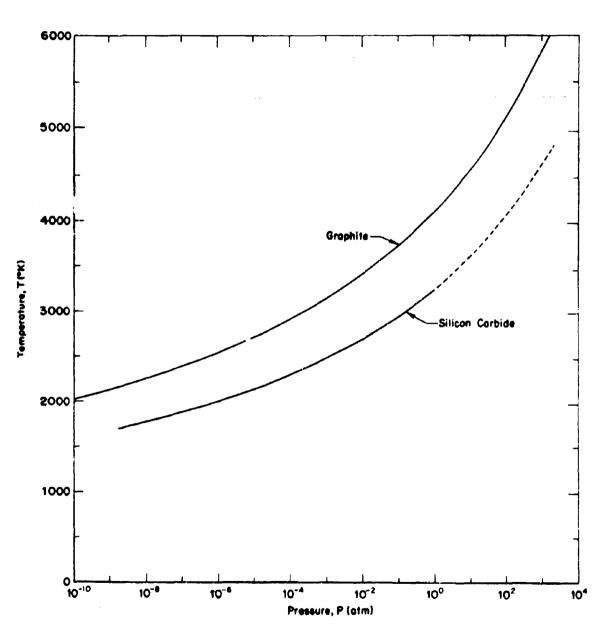


Fig. 4—Sublimation temperature for silicon carbide and graphite at various pressures

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IO. ABSTRACT

An investigation of the thermodynamic properties of silicon carbide (SiC) over a range of temperatures up to 6000°K and pressures up to 1000 atmospheres. Two sets of equilibrium composition equations are used -- one representing a pure gas phase, the other a heterogeneous system of gas and condensed (solid) silicon carbide. The gas phase of the heterogeneous chemical system, like the homogeneous gas phase, comprises 25 gaseous silicon-carbide species. Tabulated summaries give computed values of volume, molecular weight, moles of gas, moles of solid SiC, density, enthalpy, energy, and entropy for silicon carbide at various temperatures and pressures. A conventional Mollier diagram is included in which specific enthalpy is plotted against specific entropy, with cross plots of temperature, pressure, and molecular weight in the pure gas region, and cross plots of temperature and moles of condensed SiC in the gas-solid region. Variation of sublimination temperature with pressure for silicon carbide and graphite is also shown.

II. KEY WORDS

Physics Chemistry Thermodynamics